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TITLE OF THE INVENTION

OPTICAL DISK FOR MOBILE DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of Korean Patent Application Nos. 2003-17066 filed on March 19, 2003 and 2003-36742 filed on June 9, 2003, in the Korean Intellectual Property Office, the disclosure of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The present invention relates to an optical disk, and more particularly, to an optical disk for a mobile device, which is less likely to be deflected.

2. Description of the Related Art

[0003] Recently, mobile devices using a small-sized recording medium, such as digital still cameras, portable music players, and personal digital assistants (PDAs), have come into wide use. Small-sized memory cards can be used for such mobile devices, but their relatively high price makes them less attractive to customers than their cheaper counterparts, such as CD-R/RW disks. General apparatuses for recording data on and reproducing data from a CD or DVD, however, are relatively big to be carried, and thus it is necessary to develop a small-sized mobile device for recording data on or reproducing data from a CD or DVD and a disk having a new format appropriate for such a small-sized mobile device.

[0004] A conventional high-density optical disk is manufactured by recording data on a substrate having a thickness of 1.1mm and depositing an optical transmission layer on the top surface of the substrate to a thickness of 0.1mm using a spin coating or sheet bonding technique.

[0005] FIGS. 1A and 1B are a perspective view and a cross-sectional view, respectively, of a conventional optical disk 10 bent due to a process of forming an optical transmission layer.

Referring to FIGS. 1A and 1B, an optical disk 10 has an outer diameter Dout of 120mm, an inner diameter Din of 15mm, and a thickness t of 1.1mm. An optical transmission layer 13 formed on the surface of a substrate 11 has a thickness l of 0.1mm. In FIG. 1B, light perpendicularly incident to the optical transmission layer 13 is refracted after passing through the optical transmission layer 13 and reflected from an interface between the optical transmission layer 13 and the substrate 11, and then exits from the optical disk 10. As shown in FIG. 1B, the exiting light forms a predetermined angle θ (referred to as deflection angle) with the entering light. The conventional optical disk 10 has a deflection angle of 0.2° and is affected by a contractile-force-per-meter of 27 N/m.

[0006] As described above with reference to FIGS. 1A and 1B, even though an optical disk having a thickness of 1.1 mm is bent due to a process of forming an optical transmission layer, it is possible to normally drive the optical disk using a general apparatus for recording data on or reproducing data from an optical disk as long as a deflection angle of the optical disk does not exceed a standardized limit for deflection angle, which is 0.7°. However, in order to manufacture an optical disk for a mobile device, a thin substrate having a thickness of 1.1 mm or below is necessary. Since a thinner substrate is more vulnerable to a contractile force generated during the plasticization of an optical transmission layer deposited on the surface of the substrate, the substrate may be bent more severely and provide a larger deflection angle than the substrate 10 shown in FIGS. 1A and 1B. If an optical disk has a deflection angle larger than predetermined degrees, it may be impossible to normally record data on or reproduce data from the optical disk.

SUMMARY OF THE INVENTION

[0007] The present invention provides an optical disk including a substrate having a predetermined outer diameter and thickness, by which the substrate can be prevented from being bent in a process of forming an optical transmission layer.

[0008] According to an aspect of the present invention, there is provided an optical disk including a substrate, having an outer diameter not smaller than 28mm and a thickness not smaller than 0.29mm, so that a deflection angle of 0.7° or smaller can be obtained.

[0009] According to an aspect of the present invention, when the outer diameter is 30mm, the thickness is determined to be 0.30mm or larger.

[0010] According to an aspect of the present invention, when the outer diameter is 32mm, the thickness is determined to be 0.31mm or larger.

[0011] According to an aspect of the present invention, when the outer diameter is 47mm, the thickness is determined to be 0.375mm or larger.

[0012] According to an aspect of the present invention, when the outer diameter is 50.8mm, the thickness is determined to be 0.388mm or larger.

[0013] According to an aspect of the present invention, when the outer diameter is 80mm, the thickness is determined to be 0.501mm or larger.

[0014] According to an aspect of the present invention, when the outer diameter is 120mm, the thickness is determined to be 0.53mm or larger.

[0015] According to another aspect of the present invention, there is provided an optical disk including a substrate, having an outer diameter not smaller than 28mm and a thickness not smaller than 0.323mm, so that a deflection angle of 0.6° or smaller can be obtained.

[0016] According to an aspect of the present invention, an optical transmission layer having a thickness of 0.03 – 0.1mm is formed on the surface of the substrate. According to an aspect of the present invention, the optical transmission layer is formed of acrylate-based resin or polycarbonate.

[0017] According to another aspect of the present invention, there is provided an optical disk comprising a substrate, having a deflection angle *y*, a thickness *x*, and an outer diameter *z*. Here, the deflection angle *y*, the thickness *x*, the outer diameter *z* satisfy the following equation:

$$\alpha = 0.00396z^2 - 0.10096z + 4.15552$$
$$\beta = 0.00027z^2 - 0.05129z - 2.98393,$$
$$x \geq \frac{1}{\beta}\ln\left(\frac{1.1 \times y}{\alpha}\right)$$

[0018] In the above equation, α and β represent characteristic coefficients.

[0019] According to an aspect of the present invention, the deflection angle *y* is 0.6° or smaller.

[0020] According to an aspect of the present invention, the characteristic coefficients α and β are set to 4.6867 and –4.3083, respectively, when the outer diameter z is 30mm.

[0021] According to an aspect of the present invention, the characteristic coefficients α and β are set to 4.9484 and –4.3162, respectively, when the outer diameter z is 32mm.

[0022] According to an aspect of the present invention, the characteristic coefficients α and β are set to 8.9926 and –4.8605, respectively, when the outer diameter z is 50.8mm.

[0023] According to an aspect of the present invention, the characteristic coefficients α and β are set to 21.446 and –5.3843, respectively, when the outer diameter z is 80mm.

[0024] According to an aspect of the present invention, the characteristic coefficients α and β are obtained using the following equations for the thickness x and the deflection angle y:

$$\sum_{i=1}^{n} y_i \cdot \exp(\beta \cdot x_i) = \alpha \sum_{i=1}^{n} \exp(2\beta \cdot x_i)$$

$$\sum_{i=1}^{n} y_i \cdot \exp(\beta \cdot x_i) \sum_{i=1}^{n} x_i \cdot \exp(2\beta \cdot x_i) = \sum_{i=1}^{n} \exp(2\beta \cdot x_i) \sum_{i=1}^{n} x_i \cdot y_i \cdot \exp(\beta \cdot x_i).$$

[0025] According to an aspect of the present invention, an optical transmission layer having a thickness of 0.03 – 0.1mm is formed on the surface of the substrate. According to an aspect of the present invention, the optical transmission layer is formed of acrylate-based resin or polycarbonate.

[0026] According to another aspect of the present invention, there is provided an optical disk including a substrate, having an outer diameter not smaller than 30mm and a thickness not smaller than 0.40mm, so that a deflection angle of 0.7° or smaller can be obtained.

[0027] According to another aspect of the present invention, there is provided an optical disk including a substrate, having an outer diameter not smaller than 30mm and a thickness not smaller than 0.435mm, so that a deflection angle of 0.6° or smaller can be obtained.

[0028] In the present invention, it is possible to prevent a substrate from being bent in a process of forming an optical transmission layer of an optical disk by putting a limit on the diameter and thickness of the substrate.

[0029] Additional aspects and/or advantages of the invention will be set forth in part in the description which follows and, in part, will be obvious from the description, or may be learned by practice of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] These and/or other aspects and advantages of the invention will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompanying drawings of which:

FIG. 1A is a perspective view of a conventional optical disk;

FIG. 1B is a cross-sectional view of the optical disk shown in FIG. 1A;

FIG. 2A is a perspective view of an optical disk according to an aspect of the present invention;

FIG. 2B is a cross-sectional view of the optical disk shown in FIG. 2A;

FIG. 3 is a graph showing the variation of a deflection angle with respect to the outer diameter and thickness of an optical disk;

FIG. 4 is a graph showing the variation of a deflection angle with respect to the thickness of an optical disk having an outer diameter of 30 mm according to an aspect of the present invention;

FIG. 5 is a graph showing the variation of a deflection angle with respect to the thickness of an optical disk having an outer diameter of 32 mm according to an aspect of the present invention;

FIG. 6 is a graph showing the variation of a deflection angle with respect to the thickness of an optical disk having an outer diameter of 47 mm according to an aspect of the present invention;

FIG. 7 is a graph showing the variation of a deflection angle with respect to the thickness of an optical disk having an outer diameter of 50.8 mm according to an aspect of the present invention;

FIG. 8 is a graph showing the variation of a deflection angle with respect to the thickness of an optical disk having an outer diameter of 80 mm according to an aspect of the present invention;

FIG. 9 is a graph showing the variation of a deflection angle with respect to the thickness of an optical disk having an outer diameter of 120 mm according to an aspect of the present invention; and

FIG. 10 is a graph showing the variation of a characteristic coefficient α with respect to the outer diameter z of an optical disk according to an aspect of the present invention; and

FIG. 11 is a graph showing the variation of a characteristic coefficient β with respect to the outer diameter z of an optical disk according to an aspect of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0031] Reference will now be made in detail to the aspects of the present invention, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to the like elements throughout. The aspects are described below to explain the present invention by referring to the figures.

[0032] FIGS. 2A and 2B are a perspective view and a cross-sectional view, respectively, of an optical disk according to an aspect of the present invention. Referring to FIGS. 2A and 2B, an optical transmission layer 33 is formed on a substrate 31 to a thickness L of 0.03 – 0.1 mm. In order to obtain a deflection angle Φ of 0.7° or below, an optical disk 30 is manufactured so that its outer diameter D1 and thickness T can satisfy the following conditions.

[0033] When the diameter D1 is not smaller than 30mm, the thickness T needs to be 0.3 mm or larger. For example, the optical disk 30 may have an outer diameter D1 of 32 mm and a thickness T of 0.31 mm. When the diameter D1 is about 47 mm, the thickness T needs to be 0.375 mm or larger. When the diameter D1 is about 50.8 mm, the thickness T needs to be 0.388 mm. When the diameter D1 is about 80 mm, the thickness T needs to be 0.501 mm or larger. When the diameter D1 is about 120 mm, the thickness T needs to be 0.53 mm or larger.

[0034] Based on the fact that a contractile force of 27 N/m acts on an optical disk including a substrate, having an outer diameter of 120 mm, an inner diameter of 15 mm, a thickness of 0.5 mm, and an optical transmission layer, having a thickness of 0.1 mm, the optical disk 30 of an aspect of the present invention is manufactured to include the substrate 31 having an outer

diameter D1 of 50.8 mm, an inner diameter D2 of 5 mm, and a thickness of 0.5 mm. Thereafter, the contractile force-per-meter acting on the substrate 31 during the formation of the optical transmission layer 33 having a thickness L of 0.03 mm, 0.05 mm, or 0.1 mm is calculated.

[0035] Table 1 shows the variation of a deflection angle Φ with respect to the thickness L of the optical transmission layer 33 formed on the substrate 31 having an outer diameter D1 of 50.8 mm, an inner diameter D2 of 5 mm, and a thickness T of 0.5 mm. In Table 1, the thickness L of the optical transmission layer 33 varies from 0.1 mm to 0.05 mm and from 0.05 mm to 0.03 mm.

Table 1

Thickness of optical transmission layer (mm)	Contractile force (N/m)	Deflection angle (°)
0.1	104.1	0.38
0.05	52.1	0.19
0.03	31.2	0.11

[0036] As shown in Table 1, when the optical transmission layer 33 has a thickness L of 0.1 mm and the thickness T of the substrate 31 is 0.5 mm, the deflection angle of the optical disk 30 is 0.38°, which is 0.18° larger than that of a conventional optical disk. However, when the thickness L of the optical transmission layer 33 decreases from 0.1 mm to 0.05 mm and from 0.05 mm to 0.03 mm, the deflection angle decreases from 0.38° to 0.19° and from 0.19° to 0.11°, respectively.

[0037] The optical transmission layer 33 is formed by coating the surface of the substrate 31 with acrylate-based resin or a polycarbonate (PC) film using a spin coating or sheet bonding technique. However, the optical transmission layer 33 needs to be formed to have a thickness of 0.03 – 0.1mm so that the optical disk 30 can be prevented from being bent.

[0038] For example, the substrate 31 is manufactured under the following injection molding conditions: the temperature of a metal mold is 125°C at a fixed side and 128°C at a moving side, the temperature of resin is about 340°C, a holding force of 35 ton and a clamping pressure of 50 kgf are used, and mold cooling time is set to 5 seconds. In addition, the optical

transmission layer 33 is formed using resin having a viscosity of about 5,000 by rotating a spin coating apparatus at a speed of 3,000 rpm for 30 seconds.

[0039] FIG. 3 is a graph showing the results of simulations for the variation of a deflection angle with respect to the outer diameter and thickness of an optical disk formed under the above-described injection molding conditions. In the simulations, the outer diameter of an optical disk gradually varies from 30mm (inner diameter: 4mm) to 32mm (inner diameter: 4mm), from 32mm to 47 (inner diameter: 5mm), from 47mm to 50.8mm (inner diameter: 5mm), from 50.8mm to 80mm (inner diameter: 15mm), and from 80mm to 120mm (the inner diameter: 15mm), the thickness of the optical disk is fixed at 0.1 mm, and the thickness of a substrate gradually varies from 0.2mm to 0.3mm, from 0.3mm to 0.5mm, from 0.5mm to 0.7mm, from 0.7mm to 0.9mm, and from 0.9mm to 1.1mm. Here, an optical transmission layer is set to have a thickness of 0.1 mm. Referring to FIG. 3, as the outer diameter of the optical disk increases and the thickness of the optical disk decreases, a deflection angle increases. Curve fitting is performed by applying a least square method to data points shown in FIG. 3 and makes it possible to consecutively calculate the deflection angle of an optical disk with the thickness of the optical disk varying from 0.2mm to 1.4mm, as shown in FIG. 3.

[0040] The least square method is performed in the following way. First, a fitting curve is deduced from the data points shown in FIG. 3, which is shown in Equation (1) below.

$$y_i = \alpha \cdot \exp(\beta \cdot x_i) \qquad \cdots(1)$$

[0041] In Equation (1), x_i represents the thickness of an optical disk, and y_i represents the calculated deflection angle of the optical disk. α and β are characteristic coefficients. The characteristic coefficients α and β, which can minimize a summation square error (SSE) between a measured deflection angle Y_i of the optical disk and the deflection angle y_i obtained using Equation (1), are obtained using Equation (2).

$$SSE = \sum_{i=1}^{n} (Y_i - y_i)^2 \qquad \cdots(2)$$

[0042] Equations (3) and (4) are obtained by partially differentiating Equation (2) with respect to the characteristic coefficients α and β and rearranging the result of the partial differentiation while making the left side of the resulting equation equal to 0.

$$\sum_{i=1}^{n} y_i \cdot \exp(\beta \cdot x_i) = \alpha \sum_{i=1}^{n} \exp(2\beta \cdot x_i) \qquad \cdots(3)$$

$$\sum_{i=1}^{n} y_i \cdot \exp(\beta \cdot x_i) \sum_{i=1}^{n} x_i \cdot \exp(2\beta \cdot x_i) = \sum_{i=1}^{n} \exp(2\beta \cdot x_i) \sum_{i=1}^{n} x_i \cdot y_i \cdot \exp(\beta \cdot x_i) \qquad \cdots(4)$$

[0043] The characteristic coefficients α and β vary depending on the outer diameter of an optical disk having different characteristic coefficient values. Various characteristic coefficient values obtained for different outer diameter values by using Equations (3) and (4) are shown in Table 2 below.

Table 2

Outer diameter of optical disk (mm)	α	β
30	4.6867	-4.3083
32	4.9484	-4.3162
47	8.4470	-4.8578
50.8	8.9926	-4.8605
80	21.446	-5.3843
120	21.105	-5.1142

[0044] FIGS. 4 through 7 are graphs showing the results of curve fitting using data points obtained through various simulations. In FIGS. 4 through 7, a maximum allowable deflection angle is set to 0.7°, and the limit of error for the results of curve fitting is ± 20 %.

[0045] In particular, FIG. 4 is a graph showing the variation of a deflection angle with respect to the thickness of an optical disk when the outer diameter of the optical disk is 30mm and the characteristic coefficients α and β have values of 4.6867 and –4.3083, respectively. In FIG. 4, different deflection angles depending on the thickness of an optical disk having an outer diameter of 30mm are obtained using the following equation.

$$x \geq \frac{1}{\beta}\ln\left(\frac{1.2\times y}{\alpha}\right) \qquad \cdots(5)$$

[0046] Deflection angles y_i of optical disks having an outer diameter of 30mm but different thickness values x_i, for example, 0.3mm and 0.4mm, are obtained using Equation (1) and are marked in FIG. 4 with their corresponding maximum and minimum allowable deflection angles within ± 20 % error ranges. As shown in FIG. 4, if a standardized deflection angle is set to 0.7°, the thickness x_i of the optical disk having an outer diameter of 30mm needs to be 0.40mm or larger in order to obtain a deflection angle not larger than 0.7°, and the thickness of a substrate is preferably 0.3mm or larger.

[0047] FIG. 5 is a graph showing the variation of a deflection angle with respect to the thickness of an optical disk when the outer diameter of the optical disk is 32mm and the characteristic coefficients α and β have values of 4.9484 and –4.3162, respectively.

[0048] Deflection angles y_i of optical disks having an outer diameter of 30mm but different thickness values x_i, for example, 0.3mm, 0.4mm, and 0.45mm, are obtained using Equation (5) and are marked in FIG. 5 with their corresponding maximum and minimum allowable deflection angles within ± 20 % error ranges. As shown in FIG. 4, if a standardized deflection angle is set to 0.7°, the thickness x_i of the optical disk having an outer diameter of 32mm needs to be 0.41mm or larger in order to obtain a deflection angle not larger than 0.7°, and the thickness of a substrate is preferably 0.31mm or larger.

[0049] Referring to FIG. 5, the result of measuring an optical disk having a thickness T of 0.4mm shows that the optical disk has a deflection angle of 0.67°. In addition, the result of

measuring an optical disk having a thickness of 0.6mm shows that the optical disk has a deflection angle of about 0.7°. These measurement results provide a sound piece of proof that the simulation results shown in FIG. 5 are meaningful.

[0050] FIG. 6 is a graph showing the variation of a deflection angle with respect to the thickness of an optical disk when the outer diameter of the optical disk is 47mm and the characteristic coefficients α and β have values of 8.9926 and -21.446, respectively.

[0051] Deflection angles y_i of optical disks having an outer diameter of 47mm but different thickness values x_i, for example, 0.3mm, 0.4mm, and 0.515mm, are obtained using Equation (5) and are marked in FIG. 6 with their corresponding maximum and minimum allowable deflection angles within ± 20 % error ranges. As shown in FIG. 6, if a standardized deflection angle is set to 0.7°, the thickness x_i of the optical disk having an outer diameter of 47mm needs to be 0.475mm or larger in order to obtain a deflection angle not larger than 0.7°, and the thickness of a substrate is preferably 0.375mm or larger.

[0052] Referring to FIG. 6, the result of measuring an optical disk having a thickness T of 0.4mm shows that the optical disk has a deflection angle of 0.64°. In addition, the result of measuring an optical disk having a thickness of 0.515mm shows that the optical disk has a deflection angle of about 0.7°.

[0053] FIG. 7 is a graph showing the variation of a deflection angle with respect to the thickness of an optical disk when the outer diameter of the optical disk is 47mm and the characteristic coefficients α and β have values of 8.9926 and -21.446, respectively. Deflection angles y_i of optical disks having an outer diameter of 47mm but different thickness values x_i are obtained using Equation (5). In order to prevent a maximum allowable deflection angle from exceeding 0.7°, the thickness x_i of the optical disk needs to be 0.488mm or larger, and the thickness of a substrate is preferably 0.388mm or larger.

[0054] Referring to FIG. 7, the result of measuring an optical disk having a thickness T of 0.525mm shows that the optical disk has a deflection angle of 0.64°. In addition, the result of measuring an optical disk having a thickness of 0.6mm shows that the optical disk has a deflection angle of about 0.48°.

[0055] FIG. 8 is a graph showing the variation of a deflection angle with respect to the thickness of an optical disk when the outer diameter of the optical disk is 80mm and the characteristic coefficients α and β have values of 21.446 and –5.3843, respectively. Deflection angles y_i of optical disks having an outer diameter of 80mm but different thickness values x_i are obtained using Equation (5). In order to prevent a maximum allowable deflection angle from exceeding 0.7°, the thickness x_i of the optical disk needs to be 0.601mm or larger, and the thickness of a substrate is preferably 0.501mm or larger.

[0056] Referring to FIG. 8, the result of measuring an optical disk having a thickness T of 0.6mm shows that the optical disk has a deflection angle of 0.85°. In addition, the result of measuring an optical disk having a thickness of 0.635mm shows that the optical disk has a deflection angle of about 0.7°.

[0057] FIG. 9 is a graph showing the variation of a deflection angle with respect to the thickness of an optical disk when the outer diameter of the optical disk is 120mm and the characteristic coefficients α and β have values of 21.105 and –5.1142, respectively. Deflection angles y_i of optical disks having an outer diameter of 120mm but different thickness values x_i are obtained using Equation (5). In order to prevent a maximum allowable deflection angle from exceeding 0.7°, the thickness x_i of the optical disk needs to be 0.63mm or larger, and the thickness of a substrate is preferably 0.53mm or larger.

[0058] Referring to FIG. 9, the result of measuring an optical disk having a thickness T of 0.6mm shows that the optical disk has a deflection angle of 1°. In addition, the result of measuring an optical disk having a thickness of 0.67mm shows that the optical disk has a deflection angle of about 0.7°.

[0059] The above-mentioned simulation results, shown in FIGS. 4 through 9, show that the thickness of an optical disk can be controlled so as not to exceed a maximum allowable deflection angle of 0.7° and the deflection angle of the optical disk can be obtained using Equation (1) irrespective of the type of the optical disk, taking into consideration that the deflection angle of the optical disk can vary within ± 20 % of a curve fitting result. In addition, it is possible to obtain a desired thickness x_i of an optical disk with a given maximum allowable deflection angle using the characteristic coefficients α and β and Equation (1).

[0060] In other words, when the outer diameter of the optical disk is 30mm, 47mm, 50.8mm, 80mm, or 120mm under a condition that the maximum allowable deflection angle of an optical disk is set to 0.6°, the thickness of the optical disk is preferably not smaller than 0.435mm, 0.447mm, 0.5mm, 0.52mm, 0.63mm, or 0.66mm, respectively, which is shown in the following table.

Table 3

Diameter / Deflection angle	30mm	32mm	47mm	50.8mm	80mm	120mm
≥ 0.6 °	≤ 0.43mm	≤ 0.447mm	≤ 0.5mm	≤ 0.52mm	≤ 0.63mm	≤ 0.66mm
≥ 0.7 °	≤ 0.40mm	≤ 0.41mm	≤ 0.475mm	≤ 0.48mm	≤ 0.601mm	≤ 0.63mm

[0061] In addition, the variation of the characteristic coefficients α and β with respect to the outer diameter z of an optical disk can be subjected to curve fitting. FIG. 10 is a graph showing the variation of the characteristic coefficient α with respect to the outer diameter z of an optical disk, and FIG. 11 is a graph showing the variation of the characteristic coefficient β with respect to the outer diameter z of an optical disk. The characteristic coefficient α is obtained using Equation (6) below, and the characteristic coefficient β is obtained using Equation (7) below. Therefore, once the outer diameter z of an optical diameter is given, the characteristic coefficients α and β can be obtained through a fitting equation. After all, the thickness of an optical disk having a desired deflection angle can be obtained by substituting the characteristic coefficients α and β into Equation (5).

$$\alpha = 0.00396z^2 - 0.10096z + 4.1552 \quad \cdots(6)$$

$$\beta = 0.00027z^2 - 0.05129z - 2.98393 \quad \cdots(7)$$

[0062] As described above, the larger the outer diameter of an optical disk, the larger the deflection angle of the optical disk. In addition, the smaller the thickness of the optical disk, the larger the deflection angle of the optical disk. Therefore, possible matches between the outer diameter and thickness of an optical disk under a condition that the deflection angle of the optical disk is 0.7 ° or 0.6 ° are shown in Table 3. Since the thickness of an optical transmission layer is supposedly set to 0.1 mm, as described above, possible substrate thicknesses (= the thickness of the optical disk – the thickness of the optical transmission layer) for different substrate outer diameters (= the outer diameter of the optical disk) are shown in FIG. 4.

Table 4

Diameter / Deflection angle	30mm	32mm	47mm	50.8mm	80mm	120mm
≥ 0.6 °	≤ 0.33mm	≤ 0.347mm	≤ 0.40mm	≤ 0.42mm	≤ 0.53mm	≤ 0.56mm
≥ 0.7 °	≤ 0.30mm	≤ 0.31mm	≤ .375mm	≤ 0.38mm	≤.501mm	≤ 0.53mm

[0063] As described above, according to the present invention, it is possible to obtain an appropriate thickness of an optical disk with a given outer diameter of the optical disk when a deflection angle of the optical disk is set to a predetermined standardized limit, and thus it is possible to minimize the probability of a substrate of the optical disk from being bent.

[0064] The mobile optical disk of the present invention can be used as an optical recording medium for a mobile apparatus for recording data on or reading data from an optical recording medium. Especially, the mobile optical disk of the present invention can be loaded into such a mobile device using a compact-sized recording medium as a digital still camera (so called a digital camera), a portable music player, or a personal digital assistant (PDA).

[0065] Although a few aspects of the present invention have been shown and described, it would be appreciated by those skilled in the art that changes may be made in this aspect without departing from the principles and spirit of the invention, the scope of which is defined in the claims and their equivalents.